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Union County, Indiana

Pacific NW Environmental Res. Lab.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

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CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

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REPORT
ON
WHITEWATER LAKE
UNION COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 347

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
APRIL, 1976

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

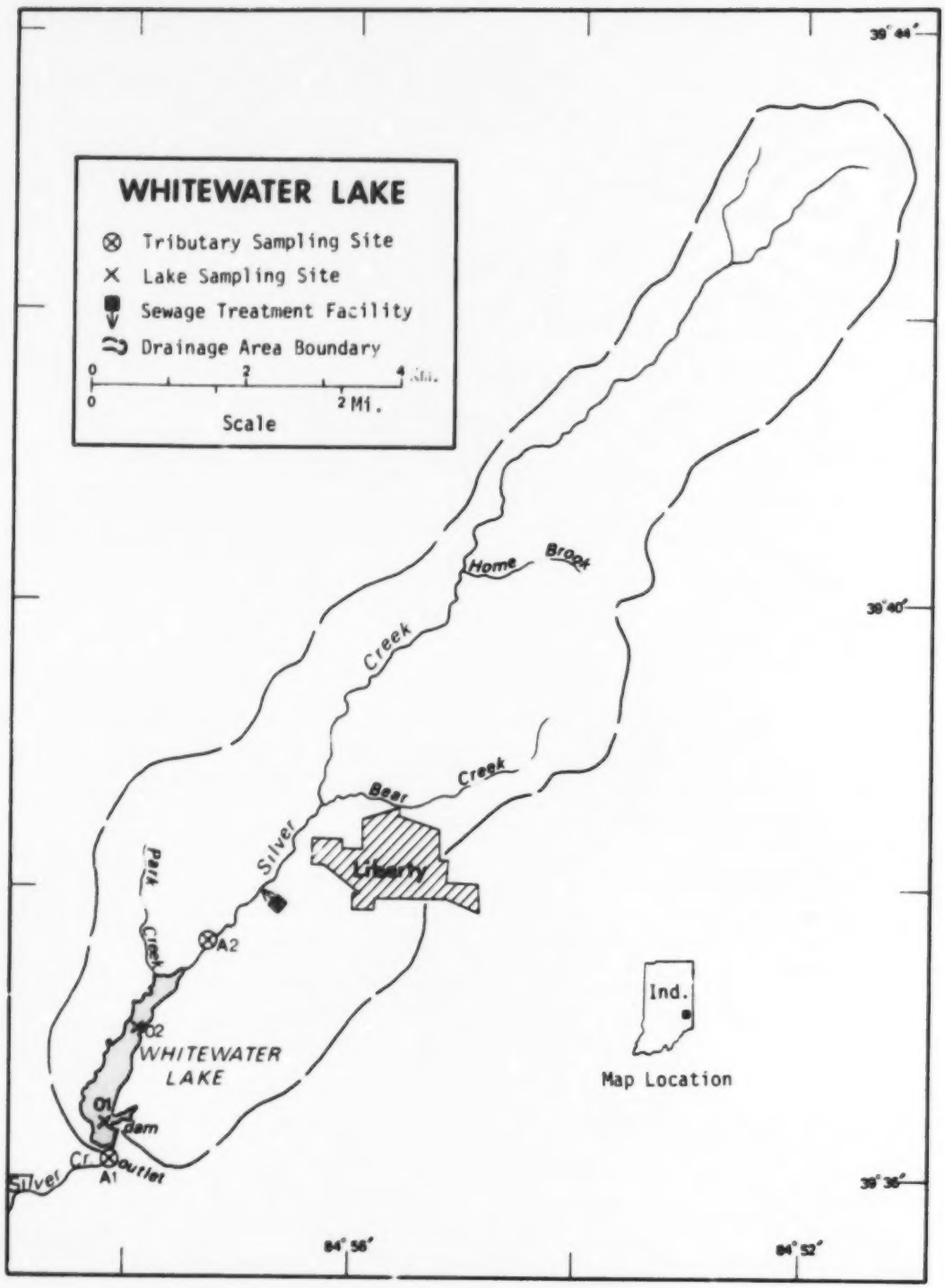
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


WHITEWATER LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
0 2 4 Km.
0 2 Mi.
Scale
39°44'
39°40'
39°36'
84°56'
84°52'
Home Brook
Creek
Beer Creek
Silver
Liberty
Port Creek
A2
02
WHITEWATER LAKE
01
Dam
Silver Cr.
A1
outlet
Ind.
Map Location

WHITEWATER LAKE

STORET NO. 1839

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Whitewater Lake is eutrophic. Of the 27 Indiana lakes sampled in 1973, it ranked twenty-fourth in overall trophic quality when compared using a combination of six parameters*. Twenty of the lakes had less and one had the same median total phosphorus, 14 had less and one had the same median dissolved phosphorus, 21 had less mean chlorophyll a, and 20 had greater mean Secchi disc transparency. Hypolimnetic depletion of dissolved oxygen occurred at station 1 in August and October.

Survey limnologists noted aquatic macrophytes near station 1 in October.

A September, 1975 study by the Indiana Division of Water Pollution Control indicates the trophic condition of Whitewater Lake may have improved since Survey sampling was completed; additional sampling will be done in the summer of 1976 to verify the apparent improvement (BonHomme, 1976).

B. Rate-Limiting Nutrient:

The algal assay results are not representative of lake conditions at the time of sampling because of nutrient losses in the sample during shipment from the field to the laboratory. However, the lake data indicate that Whitewater Lake was phosphorus limited at all sampling times.

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* See Appendix A.

C. Nutrient Controllability:

1. Point sources--Point source phosphorus contributions amounted to 23.7% of the total load reaching Whitewater Lake during the sampling year. The Liberty wastewater treatment plant contributed 23.5% of the total.

The present phosphorus loading of 3.28 $g/m^2/yr$ is four times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). Whitewater Lake is phosphorus limited, and point-source phosphorus loads should be minimized to the greatest practicable extent. Complete removal of phosphorus at the Liberty wastewater treatment plant would reduce the loading rate to 2.5 $g/m^2/yr$ and should at least slow the eutrophication occurring in the lake.

2. Non-point sources--The phosphorus contribution of non-point sources accounted for 76.3% of the total load to the lake. Silver Creek contributed 70.4%, and the ungaged tributaries were estimated to have contributed 5.3%.

The phosphorus export rate of Silver Creek was high (45 $kg/km^2/yr$) as compared to the rates of two of the tributaries of Versailles Lake*; i.e., Falling Timber Creek (9 $kg/km^2/yr$) and Cedar Creek (25 $kg/km^2/yr$). This probably was due to the proximity of the stream sampling station to the Liberty treatment plant outfall (see map, page v). Note that phosphorus concentrations in the stream varied directly with concentrations in the plant effluent (Appendix E).

* Working Paper No. 343.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 0.81 kilometers^2.
2. Mean depth: 4.6 meters.
3. Maximum depth: 14.9 meters.
4. Volume: 3.726×10^6 m^3.
5. Mean hydraulic retention time: 94 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Silver Creek	41.7	0.39
Minor tributaries & immediate drainage -	7.3	0.07
Totals	49.0	0.46

2. Outlet -

Silver Creek	49.8**	0.46**

C. Precipitation***:

1. Year of sampling: 106.6 centimeters.
2. Mean annual: 102.2 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Whitewater Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 9.4 meters at station 1 and 2.4 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR WHITEWATER LAKE
STORET CODE 1839

PARAMETER	1ST SAMPLING (4/29/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 2/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/10/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	10.6 - 14.9	13.7	14.2	12.0 - 24.9	21.7	24.6	13.7 - 23.5	20.5	21.2
DISS OXY (MG/L)	7.2 - 12.1	9.6	9.6	0.0 - 10.0	4.9	4.8	0.0 - 12.8	5.3	4.8
CNDCTVY (MCROMO)	550. - 570.	557.	555.	351. - 422.	385.	378.	355. - 452.	377.	365.
PH (STAND UNITS)	8.2 - 8.5	8.3	8.3	7.4 - 8.9	8.2	8.5	7.2 - 9.0	8.1	8.1
TOT ALK (MG/L)	204. - 270.	229.	217.	122. - 256.	155.	131.	135. - 230.	154.	141.
TOT P (MG/L)	0.059 - 0.112	0.087	0.087	0.056 - 0.101	0.077	0.077	0.056 - 0.420	0.135	0.080
ORTHO P (MG/L)	0.008 - 0.016	0.011	0.010	0.010 - 0.036	0.016	0.011	0.006 - 0.085	0.026	0.013
NO2+NO3 (MG/L)	4.200 - 4.800	4.617	4.700	0.150 - 1.410	1.023	1.235	0.030 - 0.070	0.045	0.045
AMMONIA (MG/L)	0.050 - 0.290	0.110	0.070	0.070 - 2.880	0.702	0.150	0.100 - 4.980	0.987	0.165
KJEL N (MG/L)	0.700 - 1.000	0.883	0.900	1.600 - 4.100	2.050	1.600	0.800 - 7.000	2.100	1.200
INORG N (MG/L)	4.250 - 4.890	4.727	4.805	1.300 - 3.030	1.725	1.485	0.130 - 4.940	1.032	0.210
TOTAL N (MG/L)	5.200 - 5.800	5.500	5.500	2.430 - 4.250	3.073	2.945	0.870 - 7.040	2.145	1.240
CHLRPYL A (UG/L)	18.8 - 43.1	30.9	30.9	14.1 - 61.8	37.9	37.9	14.0 - 46.7	30.3	30.3
SECCHI (METERS)	0.5 - 0.9	0.7	0.7	0.7 - 0.8	0.7	0.7	0.8 - 0.9	0.8	0.8

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/29/73	1. Flagellates	14,936
	2. *Melosira sp.*	13,553
	3. Centric diatoms	691
	4. *Cryptomonas sp.*	507
	5. *Euglena sp.*	138
	Other genera	140
	Total	29,965
08/02/73	1. *Oscillatoria sp.*	14,849
	2. *Synedra sp.*	2,787
	3. *Dactylococcopsis sp.*	2,110
	4. *Microcystis sp.*	876
	5. *Stephanodiscus sp.*	557
	Other genera	915
	Total	22,094
10/10/73	1. Coccoid Chrysophyta	24,194
	2. *Oscillatoria sp.*	13,483
	3. *Dactylococcopsis sp.*	11,341
	4. Flagellates	8,947
	5. *Microcystis sp.*	6,930
	Other genera	21,807
	Total	86,702

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
04/29/73	1	43.1
	2	18.8
08/02/73	1	14.1
	2	61.8
10/10/73	1	14.0
	2	46.7

C. Limiting Nutrient Study:

The algal assay results are not considered indicative of conditions in the lake at the time the sample was taken because of a 45% loss of orthophosphorus in the sample during shipment from the field to the laboratory. However, the lake data indicate that Whitewater Lake was limited by phosphorus; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 40/1 or greater at all sampling times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of March and April when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at stations B-1, C-1, and D-1 of nearby Versailles Lake and multiplying the means by the ZZ area in km^2.

The operator of the Liberty wastewater treatment plant provided monthly effluent samples and corresponding flow data.

The estimated phosphorus load from septic tanks was reduced by

* See Working Paper No. 175.

50% to adjust for a phosphate detergent ban which has been in effect in Indiana since January, 1972.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Liberty	1,702**	act. sludge + pond	595.6	Silver Creek

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Silver Creek	1,870	70.4
b. Minor tributaries & immediate drainage (non-point load) -	140	5.3
c. Known municipal STP's -		
Liberty	625	23.5
d. Septic tanks*** -	5	0.2
e. Known industrial - None	-	-
f. Direct precipitation**** -	15	0.6
Total	2,655	100.0

2. Outputs -

Lake outlet - Silver Creek 960

3. Net annual P accumulation - 1,695 kg.

* Swafford, 1973.
** 1970 Census
*** Estimate based on one shoreline park; see Working Paper No. 175.
**** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Silver Creek	64,345	89.2
b. Minor tributaries & immediate drainage (non-point load) -	3,425	4.7
c. Known municipal STP's -		
Liberty	3,465	4.8
d. Septic tanks* -	35	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	875	1.2
Total	72,145	100.0

2. Outputs -

Lake outlet - Silver Creek 54,900

3. Net annual N accumulation - 17,245 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Silver Creek	45	1,543

* Estimate based on one shoreline park; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	3.28	2.09	89.1	21.3

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Whitewater Lake:

"Dangerous" (eutrophic loading)	0.82
"Permissible" (oligotrophic loading)	0.41

V. LITERATURE REVIEWED

BonHomme, Harold L., 1976. Personal communication (review of preliminary report). IN Div. Water Poll. Contr., Indianapolis.

Swafford, J. R., 1973. Treatment plant questionnaire (Liberty STP). Liberty.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Div. of Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN SD	MEDIAN DISS ORTHO P
1805	CATAWACT LAKE	0.059	1.660	466.667	15.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.004
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.004
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1824	MONROE RESERVOIR	0.025	0.325	438.823	6.967	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	384.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLEW LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.980	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.467	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	464.833	47.480	14.800	0.017
1849	MOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.048	0.250	471.375	29.367	7.000	0.012
1852	CHOURED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.014	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.445	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SDD-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	274
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	469
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	488
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITMER LAKE	279
16	1840	WINONA LAKE	260
17	1911	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1839 WHITEWATER LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 49.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1839A1	51.8	0.623	0.745	1.056	0.988	0.637	0.487	0.292	0.102	0.096	0.102	0.255	0.467	0.486
1839A2	41.7	0.498	0.597	0.852	0.796	0.513	0.391	0.235	0.079	0.076	0.082	0.204	0.379	0.391
1839ZZ	7.3	0.079	0.102	0.150	0.139	0.088	0.068	0.040	0.011	0.012	0.012	0.034	0.068	0.067

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 49.7
SUM OF SUB-DRAINAGE AREAS = 49.0
TOTAL FLOW IN = 5.51
TOTAL FLOW OUT = 5.85

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1839A1	6	73	0.878	9	0.736				
	7	73	0.963	16	0.198				
	8	73	0.340	22	0.340				
	9	73	0.105	21	0.096				
	10	73	0.105	11	0.088				
	11	73	0.311	6	0.102				
	12	73	0.566	5	0.272				
	1	74	1.586	17	3.398				
	2	74	0.793	13	0.595				
	3	74	0.765	4	0.850	14	0.453		
	4	74	1.416	3	1.444	22	7.334		
	5	74	0.680	13	0.481				
1839A2	6	73	0.538	9	0.453				
	7	73	0.595	16	0.198				
	8	73	0.227	22	0.232				
	9	73	0.079	21	0.074				
	10	73	0.079	11	0.680				
	11	73	0.198	6	0.765				
	12	73	0.340	5	0.181				
	1	74	0.991	17	2.095				
	2	74	0.510	13	0.368				
	3	74	0.510	4	0.510	14	0.283		
	4	74	0.878	3	0.906	22	0.453		
	5	74	0.425	13	0.311				
1839ZZ	6	73	0.093	9	0.079				
	7	73	0.105	16	0.034				
	8	73	0.040	22	0.040				
	9	73	0.014	21	0.014				
	10	73	0.014	11	0.119				
	11	73	0.034	6	0.133				
	12	73	0.059	5	0.031				
	1	74	0.173	17	0.368				
	2	74	0.091	13	0.065				
	3	74	0.091	4	0.091	14	0.051		
	4	74	0.153	3	0.159	22	0.079		
	5	74	0.074	13	0.054				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

183901
39 36 19.0 084 58 17.0 3
WHITEWATER LAKE
18161 INDIANA

051091

11EPALES 2111202
0035 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/29	14	50 0000	14.4		36	560	8.30	204	0.080	0.900	4.700	0.008
	14	50 0004	14.1	10.8		560	8.40	204	0.060	0.900	4.700	0.010
	14	50 0015	13.4	8.5		550	8.20	260	0.130	0.700	4.700	0.013
	14	50 0031	10.6	7.2		550	8.20	270	0.290	0.800	4.600	0.016
73/08/02	09	40 0000	24.9		33	351	8.90	125	0.070	1.600	1.230	0.010
	09	40 0005	24.8	10.0		366	8.50	122	0.120	1.600	1.280	0.016
	09	40 0015	19.5	0.0		416	7.50	168	0.840	1.600	0.830	0.011
	09	40 0030	12.0	0.5		422	7.40	256	2.880	4.100	0.150	0.036
73/10/10	18	10 0000	22.4		36	355	8.90	135	0.100	1.400	0.030	0.006
	18	10 0005	21.2	4.8		357	8.10	142	0.190	0.900	0.050	0.014
	18	10 0015	20.7	3.0		367	7.60	143	0.480	1.000	0.050	0.027
	18	10 0031	13.7	0.0		452	7.20	230	4.900	7.000	0.040	0.085

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/29	14	50 0000	0.088	43.1
	14	50 0004	0.087	
	14	50 0015	0.076	
	14	50 0031	0.059	
73/08/02	09	40 0000	0.071	14.1
	09	40 0005	0.068	
	09	40 0015	0.056	
	09	40 0030	0.101	
73/10/10	18	10 0000	0.068	14.0
	18	10 0005	0.056	
	18	10 0015	0.070	
	18	10 0031	0.428	

STORET RETRIEVAL DATE 76/03/30

183902
39 39 00.0 084 57 59.0 3
WHITEWATER LAKE
18161 INDIANA

051391

11EPALES 2111202
0011 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/29	15 30	0000	14.9		18	550	8.50	230	0.050	1.000	4.200	0.009
	15 30	0008	14.8	12.1		570	8.50	204	0.050	1.000	4.000	0.011
73/08/02	10 10	0000	24.8		26	371	8.70	126	0.140	1.000	1.240	0.012
	10 10	0008	24.4	9.1		384	8.50	135	0.160	1.600	1.410	0.011
73/10/10	18 25	0000	23.5	12.8	30	363	9.00	135	0.140	1.500	0.030	0.013
	18 25	0008	21.3	6.0		368	8.10	140	0.110	0.800	0.070	0.013

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/29	15 30	0000	0.102	18.8
	15 30	0008	0.112	
73/08/02	10 10	0000	0.086	61.8
	10 10	0008	0.083	
73/10/10	18 25	0000	0.090	46.7
	18 25	0008	0.100	

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/03/30

1839A1
39 36 03.0 084 58 15.0 4
SILVER CREEK
18 7.5 FAIR FIELD
0/WHITEWATER LAKE 051091
AT BASE OF DAM SPILLWAY
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	16	30	2.400	1.980	0.028	0.012	0.095
73/07/16	14	15	1.700	1.200	0.160	0.015	0.055
73/08/22	15	00	0.072	1.610	0.012	0.018	0.090
73/09/21	10	20	0.010K	1.150	0.068	0.005K	0.060
73/10/11	13	30	0.010K	1.100	0.024	0.010	0.065
73/11/06	11	10	0.528	1.200	0.352	0.020	0.025
73/12/05	14	00	1.340	2.200	0.320	0.044	0.055
74/01/17	10	30	2.800	1.300	0.132	0.012	0.065
74/02/13	13	05	4.300	0.900	0.085	0.050	0.095
74/03/04	10	00	4.500	1.000	0.020	0.020	0.095
74/03/14	10	00	3.700	0.900	0.010	0.010	0.050
74/04/03	09	30	3.800	1.000	0.015	0.010	0.030
74/04/22	12	45	3.520	1.100	0.007	0.010	0.020
74/05/13	13	40	2.700	0.900	0.020	0.020	0.070

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1839A2
39 37 38.0 084 57 20.0 4
SILVER CREEK
18 7.5 LIBERTY
I/WHITEWATER LAKE 051391
SEC RD BRDG 1 MI SW OF LIBERTY
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	17	10	6.700	1.680	0.098	0.089	0.115
73/07/16	14	50	2.700	0.800	0.056	0.250	0.270
73/08/22	15	20	2.800	0.390	0.026	0.183	0.210
73/09/21	10	45	3.500	0.540	0.078	0.470	0.520
73/10/11	13	50	2.500	0.720	0.030	0.460	0.510
73/11/06	11	30	2.300	0.350	0.036	0.252	0.295
73/12/05	14	20	4.900	0.100K	0.044	0.120	0.140
74/01/17	10	45	8.500	0.900	0.096	0.120	0.270
74/02/13	13	20	4.850	0.500	0.030	0.045	0.065
74/03/04	10	20	5.700	0.700	0.010	0.050	0.075
74/03/14	10	30	5.100	0.300	0.020	0.060	0.075
74/04/03	09	45	5.460	0.500	0.015	0.035	0.035
74/04/22	13	00	4.100	1.400	0.060	0.070	0.100
74/05/13	14	00	2.600	0.900	0.030	0.095	0.130

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1839AA AS1839AA P001702
39 38 05.0 084 56 45.0 4
LIBERTY
18 7.5 LIBERTY
T/WHITEWATER LAKE 051391
SILVER CREEK
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/06/07	09 30		8.900	0.480	0.015	0.880	0.960	0.310	0.150
73/07/10	12 00		15.000	0.550	0.110	4.800	5.000	0.119	0.168
73/08/10	08 30		17.000	1.380	0.075	5.400	5.900	0.124	0.107
73/09/09	15 15		29.000	0.750	0.260	4.901	5.021	0.091	0.142
73/10/11	14 00		22.000	0.500K	0.012	5.550	5.700	0.077	0.094
73/11/06	12 45		21.200	0.500K	0.076	2.000	2.400	0.067	0.100
73/12/07	13 30		17.800	1.000K	0.020	1.900	2.200	0.073	0.131
74/01/10	14 00		16.000	1.000K	0.310	2.320	2.500	0.024	0.128
74/03/11	10 00		2.000	1.000K	0.050K		1.900	0.148	0.186
74/04/19	10 30		13.600	1.000K	0.061	1.600	1.700	0.176	0.196
74/05/08	10 30		19.000	1.000K	0.150	2.200	2.400	0.146	0.272
74/06/10	13 00		21.000	1.000K	0.200	2.750	3.300	0.154	0.214

K VALUE KNOWN TO BE
LESS THAN INDICATED